Simultaneous characterization of 3D absorption and grain microstructure in undeformed materials by diffraction contrast tomography

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Résumé - The principles of a novel technique for non-destructive and simultaneous mapping of the 3D grain and absorption microstructure of a material are explained. The grains are imaged using the occasionally occurring diffraction contribution to the X-ray attenuation coefficient each time a grain fulfils the diffraction condition. The 3D grain shapes are reconstructed from a limited number of projections using an algebraic reconstruction technique.

In recent years EBSD has become an enormously important technique for the characterisation of polycrystalline microstructures in materials science and engineering. However, without destructive sectioning techniques it is limited to two dimensional surface measurements.

Here we describe a technique based on synchrotron x-ray imaging which has been used to produce full 3D grain maps (both grain shapes and orientations) in annealed aluminium alloy and stainless steel samples containing around 500 grains. The technique is termed diffraction contrast tomography [1,2], underlining its similarity to conventional absorption contrast tomography with which it shares a common experimental setup.

The sample is illuminated using a highly monochromatic synchrotron x-ray beam. Grains are imaged using the extinction contrast that appears in the transmitted beam during rotation of the sample when grains are aligned in the diffraction condition. The beams of radiation diffracted by the grains are captured simultaneously on the same detector as the direct beam image. The combination of diffraction and extinction information greatly aids the grain indexing operation, in which extinction images are assigned to grain sets. Grain shapes are determined by algebraic reconstruction from the limited number of extinction projections, while grain orientation is found from the diffraction geometry.

The potential and the limitations of the technique will be illustrated on recent applications such as the study of stress corrosion and fatigue crack propagation mechanisms.

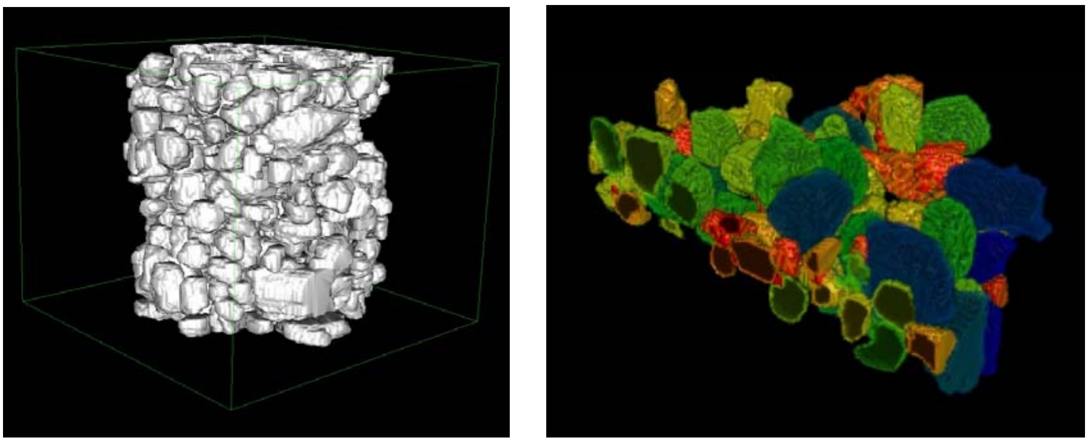

Figure 1 *- Some examples of 3D polycrystalline microstructure imaged using diffraction contrast tomography*

Références

[1] W. Ludwig, S. Schmidt, E.M. Lauridsen, H.F. Poulsen, *Diffraction contrast tomography: a novel technique for 3D grain mapping in polycrystals. Part I: direct beam case*, J. Appl. Cryst., submitted

[2] G. Johnson, A. King, M. Gonzalves-Hoennicke, W. Ludwig, *Diffraction contrast tomography: a novel technique for 3D grain mapping in polycrystals. Part II: the combined case*, J. Appl. Cryst., submitted

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